Travel, Emissions, and Welfare Effects of Travel Demand Management Measures

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Land-use intensification measures and pricing policies are compared and combined with high-occupancy vehicle (HOV) lane and light-rail transit expansion scenarios in the Sacramento, California, region and evaluated against travel, emissions, consumer welfare, and equity criteria. A state-of-the-practice regional travel demand model is used to simulate the travel effects of these scenarios. The Small and Rosen method of obtaining consumer welfare is applied to the mode-choice models in the travel model. The most politically feasible scenarios were found to provide at best only modest improvements in congestion and emissions. Welfare losses were obtained for the HOV lane scenario, suggesting that care must be taken in project planning to ensure that savings in travel time are large enough to offset the unobserved cost of increased travel by car. Transit investment and supportive land-use intensification provided larger reductions in congestion and emissions and increased consumer welfare for all income classes. As a group, the scenarios that included pricing policies provided the greatest reduction in travel delay and emissions, increased total consumer welfare, and imposed losses on the lowest income group. However, it may be possible to combine pricing policies with more significantly expanded transit and roadway capacity and compensatory payments to increase consumer welfare for all income classes.

Many general overviews of transportation demand predict worldwide increases in vehicle kilometers traveled (VKT) and mobile emissions resulting from higher incomes, the shift to more energy-intensive modes (*1*), and vehicle growth rates that exceed population growth, particularly in developing countries (*2*). In the United States, lower out-of-pocket travel costs, decentralized basic employment (*3*), and shelter costs that have increased in proportion to income (and thus households trade longer commutes for cheaper housing) have increased VKT, energy use, and mobile emissions. All these trends have caused concern, and attention has focused on travel demand management measures (TDMs). The federal Clean Air Act requires annual reductions in nonattainment pollutants. The California Clear Air Act requires reductions in the growth rate of VKT, increases in average vehicle occupancy during commute periods, and no net increase in mobile emissions after 1997. Both acts require the adoption of all feasible transportation control measures.

In this study, land-use intensification measures and pricing policies are compared and combined with high-occupancy vehicle (HOV) lane and light-rail transit expansion scenarios in the Sacramento region of California. A state-of-the-practice regional travel demand model (SACMET 94) is used to simulate the travel effects of different scenarios, and California emissions models (DTIM2 and EMFAC7F) are used in the emissions analysis. The Small and Rosen method (*4*) of obtaining consumer welfare from discrete-choice models is applied to the mode-choice models in the travel model. The scenarios are evaluated against travel, emissions, total consumer welfare, and equity criteria.

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LITERATURE REVIEW

Considerable research has been done in the United States and elsewhere on TDMs, which may be generally categorized as land-use and travel-pricing measures. A number of studies have found that higher density cities reduce VKT per capita (*5–8*). Studies of higher densities near transit indicate reductions in automobile travel on the order of 4 percent over 30 years in the Seattle region (*7*), 14 percent over 20 years in Portland, Oregon (*9*), and 20 percent over 20 years based on a review of several simulation studies in the United States (*10,11*). Other studies indicate that land-use measures effectively reduce automobile travel or are made more effective when combined with travel-pricing policies or improved transit and walk and bike facilities (*6,12*). In general, reduced emissions are assumed to result from reduced automobile travel. However, Watterson (*7*), in a study of the Seattle region, found that the concentration of travel in higher density centers left the peripheral areas less congested. As a result, people traveled farther in those areas and the anticipated reductions in emissions were not achieved.

Many studies indicate travel-pricing measures to be effective at reducing automobile travel and emissions. Cameron's simulation study of automobile pricing in Southern California (*13*) found that VKT could be reduced by about 12 percent and pollutants could be reduced by about 20 percent with a peak-period road congestion charge of $0.15 per 1.6 km (1 mi), employee parking charges of $3 per day, retail and office parking charges of $0.60 per hr, emissions fees averaging $110 per year per vehicle, and deregulated transit services. Wilson and Shoup's empirical studies (*14*) of large employer sites indicate 20 to 30 percent reductions in commutes to sites when employees pay fully for their parking.

Other studies indicate that the effects of pricing automobile travel vary according to the quality of the alternative modes available and the nature of the charging scheme. May and Scheuernstuhl (*15*) reviewed evidence, including the Singapore downtown a.m. cordon charge of $2.50, which reduced morning downtown-bound traffic by about 44 percent, and the Bergen, Oslo, and Trondheim toll rings, which charge from $0.80 to $1.60 per trip all day and reduced traffic by only a few percentage points.

An international comparison performed with travel and land-use models found that pricing policies were more effective when accompanied by density increases near transit, improved transit service, and slower automobile speeds (*6*). Jones's review of congestion charges in Europe (*16*) found that, in low-density urban regions with poor transit service, peak-period tolls are more likely to spread the peak and suppress trips than to cause a switch in modes. If densities are high, good transit service is available, and road charges are high, then mode switching was predicted to be the prevalent response. Mogridge (*17*) points out that pricing may not be effective in very large urban areas with excellent transit service where pricing automobile use at peak periods per se may not reduce VKT because of pent-up demand.

Road pricing has been advocated by economists for decades. Morrison's review of the literature (*18*) indicates a large potential welfare benefit from road charges. Starkie's review (*19*) finds that economic efficiency requires carpool or bus-only lanes to speed up local and express bus transit, more rail transit, and toll roads as well as free roads, all to improve competition among modes.

Studies have indicated that tolls can benefit all income groups (*20*,*21*). Small's recent paper (*22*) develops a spending program for anticipated revenues from Southern California pricing policies (*13*). He demonstrates financial benefits to all consumers when pricing policies are combined with tax rebates and transit improvements.

METHODS

Travel Demand Modeling

This study uses the 1994 Sacramento regional travel demand model (SACMET 94) (*23*). The model was developed with a 1991 travel behavior survey conducted in the Sacramento region. Some of the key features of this model are the following:

1. Model feedback of assigned travel impedances to the trip distribution step;
2. Automobile ownership and trip generation steps with accessibility variables;
3. Joint destination and mode-choice model for work trips;
4. Mode-choice model with separate walk and bike modes, walk and drive access modes, and two carpool modes (two and three or more occupants);
5. Land use, travel time and monetary costs, and household attribute variables included in the mode-choice models;
6. All mode-choice equations in logit form;
7. Trip assignment step that assigns separate a.m. peak, p.m. peak, and off-peak periods; and
8. HOV lane-use probability model.

Emissions Model

The California Department of Transportation's Direct Travel Impact Model 2 (DTIM2) and the California Air Resources Board's EMFAC7F model were used in the emissions analysis. The outputs from the travel demand model used in the emissions analysis included the results of assignment for each trip purpose by each time period (a.m. peak, p.m. peak, and off peak). The Sacramento Area Council of Governments (SACOG) provided regional cold-start and hot-start coefficients for each hour in a 24-hour summer period.

Consumer Welfare Model

Kenneth Small and Harvey Rosen (*1*) show how a consumer welfare measure known as compensating variation (CV) can be obtained from discrete choice models:

$$CV = -1 / \lambda\{[\ln \textstyle\sum_{m\epsilon M} e^{Vm(pf)}] - [\ln \textstyle\sum_{m\epsilon M} e^{Vm(p0)}]\} \qquad (1)$$

where λ is the individual's marginal utility of income, V_m is the individual's indirect utility of all m choices, p^0 indicates the initial point (i.e., before the policy change), and p^f indicates the final point (i.e, after the policy change). The change in indirect utility is converted to dollars by the factor, $1/\lambda$, or the inverse of the individual's marginal utility of income. Small and Rosen show how marginal utility of income can be obtained from the coefficient of the cost variable in discrete choice models.

The compensating variation formula (1) from above was adapted to suit the specifications of the SACMET 94 mode choice models. In these models, households are segmented into income/worker categories and person trips are generated for those categories. To obtain compensating variation for each income/worker category *h* the following formula was applied for all modes m and for all trips Q between all origins *i* and all destinations *j*:

$$CV_h = -1 / \lambda_h\{\textstyle\sum_{i\epsilon I} \sum_{j\epsilon J}[(\ln \sum_{m\epsilon M} e^{Vijmh(pf)} * Q_{ijh}) - (\ln \sum_{m\epsilon M} e^{Vljmh(p0)} * Q_{ijh})]\} \qquad (2)$$

where λ_h is provided by the coefficient of the cost variable in the mode choice equations. Total compensating variation was obtained by summing the compensating variation obtained from each income/worker group. Estimates of the marginal utility of net household income by trip purpose used in the compensating variation calculations are presented in Table 1. The distribution of income used in the SACMET 94 model is empirical. Net income, not gross income, is used in the SACMET 94 mode-choice model.

Some Issues of Uncertainty in Methods of Analysis

SACMET 94 uses fixed zonal land use projections; the effect of changes in travel accessibility on population and employment location is not simulated in the model. As a result, the model

TABLE 1 Estimates of Marginal Utility of Income

Income Groups	Home-Based Work	Home-Based Shop and Other
Income Group 1 (0 to $10,000)	0.5399	1.0900
Income Group 2 ($10,001-$35,000)	0.2764	0.5580
Income Group 3 ($35,001 and above)	0.1372	0.2770

underestimates induced automobile travel as a result of major roadway capacity expansions and reduced automobile travel because of transit investments and pricing policies.

SACMET 94 is fully iterated on travel impedances with full feedback of impedances from the trip assignment step to the trip distribution step. Thus, the model assumes system equilibrium, an elasticity of demand with respect to a capacity of about 1.0. If the actual transportation system does not attain complete equilibrium (as some research suggests), the model would exaggerate the trip length in scenarios with expanded roadway capacity. However, this exaggeration may be offset by the failure to represent changes in land use resulting from transportation policies.

In SACMET 94, the trip assignment step is sensitive only to travel times on roadways and not to travel costs. Thus, a toll on a specific route would cause mode shifts but not route shifts, and the model may slightly overestimate mode shifts and underestimate route shifts. However, this bias is minimal for the results of peak-period tolls in this study because of the small portion of commute trips on congested roads and the low average toll ($0.05).

The propensity for automobile drivers to switch to transit and HOV modes in the presence of higher automobile travel time and cost is probably underestimated in the SACMET 94 model. This is an artifact of the cross-sectional data used to estimate the model. Sacramento currently has minimal transit service, one relatively short HOV facility, and comparatively low land-use densities (compared with urban areas with high transit use), and thus cross-sectional data on travel behavior collected in this area would contain little variation in transit and HOV mode choice. In addition, if land-use densities increased, transit and HOV use probably would be underestimated.

Because of the issues of uncertainty related to the methods used in this paper, predicted values should be used only to rank order scenarios for sketch planning purposes.

ALTERNATIVES MODELED

No-Build

In this alternative, new HOV lanes and transit projects listed in the Sacramento Region's 1993 Metropolitan Transportation Plan (MTP) and included in SACOG's 2015 network files were removed. Road widening and new interchange projects were maintained in the network files.

Light-Rail Transit

New light-rail transit projects listed in the 1993 MTP (approximately 98.4 track km) were added to the no-build network.

HOV Lanes

This alternative adds all new HOV lanes described in the 1993 MTP (approximately 295.2 lane km) to the no-build network.

Pricing and No-Build

Peak-period road pricing, parking pricing, and a fuel tax were added to the no-build network in this alternative. The peak-period road pricing charge on home-based work trips was set at 10 cents per 1.6 km (1 mi) on freeways and expressways with levels of service E and F. Parking pricing was represented in the model by doubling existing average daily parking charges and by adding a $2.00 parking charge to zones without parking charges. The fuel tax in this scenario is $2.00 per 3.8 L (1 gal). The long-run elasticity of demand for travel with respect to fuel cost is about –0.3 because of a shift to vehicles with higher kilometers per gallon. As a result, the fuel tax is adjusted to $0.60 per 3.8 L. The fleet was assumed to travel 32 km (20 mi) per 3.8 L. Hence, for every 1.6 km, the automobile operating cost was increased to 3 cents.

Pricing and Light-Rail Transit

In this alternative, peak-period road pricing, parking pricing, and a fuel tax were added to the light-rail transit network.

Pricing and HOV Lanes

Peak-period road pricing, parking pricing, and a fuel tax were added to the HOV lane network in this alternative.

Super Light-Rail and Transit Centers

Light-rail lines were extended to cities toward the western edge of the urban area (Woodland and Davis), two new lines were added in the southern area of the region, and three concentric lines were added in central areas of the region (Carmichael, Rancho Cordova, Fair Oaks, and Citrus Heights areas). Feeder bus routes were added or extended to serve the new lines. In addition, headways on all bus and light-rail routes were reduced by one-half.

Transit centers were represented in the model by moving growth in households, retail employment, and nonretail employment from 1990 to 2015 in the outer zones (farther than 4.8 km or 3 mi from light-rail lines) to within a 1.6-km radius of the light-rail stations until the density cap (15 households per 0.4 hectare, 10 retail employees per 0.4 hectare, and 20 nonretail employees per 0.4 hectare) was met (0.4 hectare = 1 acre). The ratios of the household classifications were held constant in all zones in the input files, and thus only the total number of households changed in the zones. This did not change the total number of households or the number of households in each income class. Forty-five transit centers were created with increased household growth of 10.6 percent, retail growth of 8.4 percent, and nonretail growth of 6.8 percent in the centers. The pedestrian environmental product was increased in all zones within the transit center radius and the zonal location of school enrollment was adjusted to correspond to changes in household location.

FINDINGS AND DISCUSSION

Travel Results

The results of the daily travel projections for the year 2015 scenarios in the Sacramento region are presented in Table 2. The only scenarios that resulted in significantly reduced vehicle trips were those that included pricing policies; the changes in trips for all other scenarios were small enough to be considered not significantly different

TABLE 2 Year 2015 Scenarios for Sacramento Region: Daily Vehicle Travel Projections

Scenarios	Trips (millions)	Kilometers Traveled (millions)[a]	Hours of Delay (thousands)
No-Build	7.5	115.2	389.5
Light Rail	7.5 (0%)[b]	115.2 (0%)	382.3 (-2%)
HOV	7.5 (0%)	118.3 (3%)	379.6 (-3%)
Pricing & No-Build	7.0 (-7%)	104.3 (-9%)	268.8 (-31%)
Pricing & Light Rail	7.0 (-7%)	104.2 (-10%)	262.7 (-33%)
Pricing & HOV	7.1 (-5%)	107.8 (-6%)	246.3 (-37%)
Super Light Rail & Transit Centers	7.5 (0%)	110.3 (-4%)	366.9 (-6%)

[a] 1 kilometer = 0.6 miles
[b] Figures in parentheses are percent change from the no-build scenario.

from the no-build scenarios. When combined with pricing policies, the no-build and light-rail scenarios produced a slightly greater reduction in vehicle trips (–7 percent) than did the HOV scenario (–5 percent).

With respect to VKT, the pricing policies as a group provided the greatest reduction from the no-build scenario; however, the addition of pricing to the no-build and light-rail scenarios produced greater reductions in VKT (–9 and –10 percent, respectively) than the addition of pricing to the HOV scenario (–6 percent). The change in VKT for the light-rail scenario is negligible, but the super-light-rail and transit centers scenario produced a reduction in VKT of 4 percent. The HOV scenario resulted in a VKT increase of 3 percent.

All scenarios tended to reduce vehicle hours of delay (VHD) over the no-build scenario. VHD are vehicle hours traveled under congested speeds minus vehicle hours of travel under free-flow speeds on the same facility. The greatest reductions were obtained from those scenarios that included pricing and capacity additions, that is, pricing and light rail (–33 percent) and pricing and HOV (–37 percent), followed by the pricing and no-build scenario (–31 percent). The next greatest reduction was achieved by the super-light-rail and transit centers scenario (–6 percent), which was followed by the HOV scenario (–3 percent). The light-rail scenario produced the smallest reduction in VHD (–2 percent).

The results of the daily mode share projections for the year 2015 scenarios in the Sacramento region are presented in Table 3. In general, the scenarios that included pricing policies tended to be most effective in reducing the drive-alone mode shares and increasing the shared ride, transit, walk, and bike mode shares, followed by the

TABLE 3 Year 2015 Scenarios for Sacramento Region: Daily Mode Share Projections

Scenarios	Drive Alone	Shared Ride	Transit	Walk & Bike
No-Build	49.2%	42.0%	0.9%	7.9%
Light Rail	49.1% (0%)[a]	41.9% (0%)	1.00% (11%)	7.9% (0%)
HOV	49.1% (0%)	42.2% (1%)	0.9% (0%)	7.8% (-1%)
Pricing & No-Build	43.1% (-12%)	45.1% (7%)	1.5% (67%)	10.3% (30%)
Pricing & Light Rail	42.9% (-13%)	44.9% (7%)	1.8% (100%)	10.3% (30%)
Pricing & HOV	43.1% (-12%)	45.1% (7%)	1.5% (67%)	10.3% (30%)
Super Light Rail & Transit Centers	48.0% (-2%)	41.4% (-1%)	1.6% (78%)	9.1% (15%)

[a] Figures in parentheses are percent change from the no-build scenario.

super-light-rail and transit centers scenario. The light-rail and HOV-lane scenarios resulted in very little overall change in mode shares from the base-case scenario.

The pricing and no-build scenario was virtually as effective in shifting mode shares as the pricing with HOV and pricing with light-rail scenarios. SACMET 94 uses an HOV lane-use model estimated from survey data that "predicts the probability that an HOV driver will utilize the freeway HOV lane based on measures of travel time savings, difficulty weaving, distance of travel on the freeway and trip purpose" (*23*). Thus, the effective capacity of HOV lane expansion is limited.

The percentage change in transit mode share is relatively large in scenarios with expanded transit and pricing policies; however, the transit mode share remained small compared with shares for other modes. This is because modest transit expansion in this region still leaves most households without bus and light-rail service. The super-light-rail and transit centers scenario increased the transit mode shared by only 0.7 percentage points, again because of poor transit service overall. The pricing policies produced increases of an equivalent or slightly greater magnitude, suggesting that transit travel tends to be slower than automobile travel and that tolls and parking charges on cars are needed to make transit competitive.

To summarize, the scenarios that included pricing policies (with relatively large charges) produced the greatest reduction in vehicle trips, VKT, and VHD. The pricing and HOV scenario was least effective in reducing trips and VKT; however, the pricing and HOV scenarios provided the greatest reduction in VHD. The super-light-rail and transit centers scenario produced the next greatest overall reduction in VKT and VHD. The HOV and light-rail scenario produced the smallest changes in trips, VKT, and VHD. With respect to mode share, pricing policies produced the greatest reduction in drive-alone mode share and the greatest increase in shared ride, transit, walk, and bike mode share. The super-light-rail and transit centers scenario is the next most effective at shifting mode share, followed by the light-rail and HOV scenarios. The finding that the light-rail and HOV scenarios have little effect on trips, VKT, VHD, and mode share is significant because these scenarios are considered to be more politically feasible than the other scenarios examined.

Emissions

The results of the daily emissions projections for the year 2015 scenarios in the Sacramento region are presented in Table 4. In general, the pricing scenarios resulted in the greatest reductions in emissions over the no-build scenario. The pricing and HOV scenario increased the reduction of total organic gases (TOG), carbon monoxide (CO), and particulate matter (PM) and decreased the reduction in nitrogen oxides (NOx) over the other pricing scenarios. The super-light-rail and transit centers scenario was the next most effective in reducing emissions. The light-rail scenario achieved negligible reductions. The HOV lane scenario, however, resulted in an increase in all emissions.

Consumer Welfare

Results of the analysis of total consumer welfare analysis are presented in Table 5. Measures of compensating variation could be obtained only for the home-based work, shop, and other trip purposes (63 percent of the region's total trips) because other trip purposes in SACMET 94 lacked the cost and income variables needed for the analysis. In addition, the capital, operation, maintenance, and external costs of the scenarios are not included in the analysis. As a result, the scenarios that include the light-rail, super-light-rail, and HOV projects would drop substantially in net benefits because of cost increases in all three categories.

The super-light-rail and centers scenario provided the largest benefits, \$0.32 per trip, because of the reduction in transit travel time. Pricing policies combined with comparatively modest or no capacity expansion, and thus modest time savings, produced the next greatest consumer welfare benefits, ranging from \$0.26 to \$0.27 a trip. We assume that pricing charges from the policies are returned

TABLE 4 Year 2015 Scenarios for Sacramento Region: Daily Emissions Projections

Scenarios	TOG (metric ton)[a]	CO (metric ton)	NOx (metric ton)	PM (metric ton)
No-Build	34.3	228.2	78.5	19.5
Light Rail	34.2 (0%)[b]	228.2 (0%)	78.6 (0%)	19.5 (0%)
HOV	34.7 (1%)	233.9 (3%)	81.5 (4%)	20.1 (3%)
Pricing & No-Build	31.4 (-8%)	207.9 (-9%)	72.7 (-7%)	17.7 (-9%)
Pricing & Light Rail	31.4 (-9%)	208.1 (-9%)	72.8 (-7%)	17.7 (-9%)
Pricing & HOV	29.8 (-13%)	205.3 (-10%)	74.2 (-6%)	17.7 (-9%)
Super Light Rail & Transit Centers	33.3 (-3%)	220.6 (-3%)	75.5 (-4%)	18.5 (-5%)

[a] 1 metric ton = 1.1 ton
[b] Figures in parentheses are percent change from the no-build scenario.

TABLE 5 Year 2015 Scenarios for Sacramento Region: Daily Compensating Variation Measure of Consumer Welfare

Scenarios	Total in Dollars	Per Trip in Dollars
Light Rail	120,005.05	0.02
HOV	-310,142.69	-0.04
Pricing & No-Build	1,915,367.93	0.26
Pricing & Light Rail	1,918,883.66	0.26
Pricing & HOV	1,935,567.78	0.27
Super Light Rail & Transit Centers	2,362,464.06	0.32

to the consumers—for example, through lower taxes. The light-rail scenario also provided a modest consumer benefit of $0.02 per trip. However, the HOV-lane scenario produced a loss in consumer welfare. This is because the time savings gained in this scenario are not large enough to offset the unobserved cost ($0.35 per 1.6 km) of additional automobile travel. Because the mode-choice models include perceived operating costs ($0.05 per 1.6 km) instead of actual operating costs, total VKT is obtained from the model, divided by 1.6, and then multiplied by $0.35. Based on a review of the literature, we assume total operating costs are $0.40 per 1.6 km (*24*). The change in total operating costs per kilometer from the base case and the alternative modeled is then added to the compensating variation figure.

The results of the daily compensating variation measure of consumer welfare by income class projections for the year 2015 scenarios in the Sacramento region are presented in Table 6. In general, income class three obtains the largest portion of the welfare gain because it has the highest income and thus makes more trips (approximately 75 percent of total trips) and has the highest value of travel time. In the pricing scenarios, the lowest income group bore losses of consumer welfare on the order of $0.24 to $0.25 per trip because of comparatively low travel time savings and low time values. All income groups benefited from the light-rail scenario and super-light-rail with transit centers scenario; however, the lowest income group benefited the least in absolute terms. The super-light-rail and centers scenario reduced transit travel time and reduced automobile travel, and thus automobile travel costs, to substantially benefit all classes. Generally, the losses among income groups for the HOV scenario were not significantly different.

To summarize, in the pricing policy scenarios, perceived automobile operating costs begin to approach the actual costs, resulting in more efficient use of existing and added HOV and transit capacity. When the perceived cost of travel does not match the actual cost, new HOV capacity induces additional automobile travel, the increased full cost of which exceeds the reductions in travel time cost because of the improvements. Significantly expanded transit capacity and intensified land uses serve to lower transit travel time costs and thus increase consumer welfare. Pricing policies may be inequitable without compensatory payments (e.g., lower taxes and exemptions from certain charges) or investment programs (e.g., expanded transit). Light-rail expansion benefited all income classes.

CONCLUSIONS

A number of general conclusions about future transportation alternatives in the Sacramento region can be drawn from these findings. First, the alternatives examined in this study that would generally be considered the most politically feasible (i.e., the light-rail and HOV-lane scenarios) provided at best only modest improvements in congestion and emissions. Second, the consumer welfare results of the HOV-lane scenario suggest that not all roadway-capacity expansion

TABLE 6 Year 2015 Scenarios for Sacramento Region: Daily Compensating Variation Measure of Consumer Welfare by Income Class

Scenarios	Income Class One ($0 to $10,000)		Income Class Two ($10,001-$35,000)		Income Class Three ($35,001 and above)	
	Total	Per Trip	Total	Per Trip	Total	Per Trip
Light Rail	278.77	0.00	13,647.30	0.01	106,078.98	0.02
HOV	-2,156.23	-0.03	-69,722.99	-0.04	-238,263.47	-0.04
Pricing & No-Build	-16,109.06	-0.24	115,450.40	0.07	1,816,026.59	0.32
Pricing & Light Rail	-16,752.57	-0.25	105,589.16	0.07	1,830,047.07	0.33
Pricing & HOV	-16,702.86	-0.25	121,994.95	0.08	1,830,275.69	0.33
Super Light Rail & Transit Centers	12,908.73	0.09	277,208.28	0.17	2,072,347.05	0.37

projects will produce consumer benefits. Care must be taken in planning roadway projects to ensure that the travel time savings obtained from projects are large enough to offset the unobserved cost of additional automobile travel. Third, transit investment and supportive land-use intensification provide larger reductions in congestion and emissions and increase consumer welfare for all income classes. Finally, as a group, the scenarios that included aggressive pricing policies provided the greatest reduction in travel delay and emissions, increased total consumer welfare, and imposed losses on the lowest income group. However, it may be possible to combine pricing policies with more significantly expanded transit and roadway capacity (than examined in this study) or compensatory payments to increase consumer welfare for all income classes.

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